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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM OF THE

MINNEAPOLIS MEETING

AT

THE UNIVERSITY OF MINNESOTA

JUNE 21 and 22, 1935

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AMERICAN PHYSICAL SOCIETY

MINNEAPOLIS MEETING, JUNE 21–22, 1935

THE 199th regular meeting of the American Physical Society will be held at the University of Minnesota, Minneapolis, Minnesota on Friday and Saturday, June 21 and 22, 1935.

All scientific meetings will be held in the Physics Building of the University of Minnesota. The first session will be at 9:30 o'clock Friday morning, June 21. Titles and abstracts of the papers to be presented at this session are given in the following pages.

Registration. Registration will begin at 8:30 Friday morning in the lobby of the Physics Building.

Accommodations. Pioneer Hall, the men's dormitory of the University, will be used for housing members and their guests, including ladies. Accommodations in Pioneer Hall will be available beginning with dinner Thursday evening, June 20, and continuing through the American Association for the Advancement of Science meeting the following week. The rate will be approximately $2.25 per person per day, American plan. Requests for reservations by letter, or on the return card which was sent to all members in April, should reach Minneapolis not later than June 17.

Those who may prefer accommodations in a hotel should write directly to the hotel. Hotel rates, European plan: Nicollet Hotel, with bath, single, $2.50 and up, double, $4.00 and up. Curtis Hotel, with bath, single, $2.00 and up, double, $3.00 and up. Radisson Hotel, with bath, single, $3.00 and up, double, $4.50 and up. Hotels are about twenty minutes from the Campus by street car.

Entertainment. At 10:30, Friday morning, the ladies in attendance at the meeting are invited to drive to points of interest in the city and to attend a luncheon at the Woman's Club at 1:00 P.M.

On Friday evening at 7:00 o'clock a dinner followed by an informal assembly will be held at the Automobile Club of Minneapolis on the bluffs overlooking the Minnesota River valley. Tickets for the dinner should be purchased at the registration desk. The group should plan to leave Pioneer Hall or the Physics Building at about 6:00 P.M.

On Saturday afternoon a picnic will be held on the shores of Lake Minnetonka. Transportation will be provided for those who have no cars.

Informal dress at all functions will be in order.

Sports. Those wishing to play golf may obtain guest cards entitling the holder to the privileges of the Midland Hills Country Club or the University of Minnesota Golf Course. Guest cards should be obtained at the registration desk. Those wishing to play tennis will find numerous courts on the Campus within a short distance of Pioneer Hall.

Swimming and other sports will be in order at the picnic.

More complete information regarding sports will be available at the registration desk in the Physics Building.

Railroads. Those coming on the railroad will find that summer excursion rates are available from most points. It may be necessary in some cases to purchase excursion tickets to Excelsior or Wayzata (Lake Minnetonka) rather than to

Minneapolis but such tickets may be validated in Minneapolis. Members of the A.A.A.S. may use the certificate plan and obtain a round trip for one and one-third fares. Certificates can be validated at the registration desk of the A.A.A.S. beginning Monday, June 24. (See the May 24, 1935 issue of *Science* for detailed information of this plan. It is possible that the dates covered by the certificate plan will be extended. See current issues of *Science*.) In most cases the summer excursion rates will be less than the certificate plan fares. Each one should consult his local ticket agent for the best possible railroad rates.

Automobile. Minneapolis may be reached by paved highways from all directions. An automobile map of Minnesota will be sent to all members who have indicated on the return card sent them in April that they expect to drive.

Vacation facilities. Minnesota, particularly the northern part, offers ideal vacation facilities for those who may wish to avail themselves of them. Information concerning various lake and forest resorts will be sent to all those who have indicated on their return cards that they desire it.

American Association for the Advancement of Science. The annual meeting of the American Association for the Advancement of Science will convene in Minneapolis on Monday following the meeting of the American Physical Society. The program of this meeting will be announced in *Science*. Section B—Physics will meet in joint session with Section A—Mathematics on Tuesday morning, June 24. The general subject of the three invited papers to be presented concerns approximation methods for the solution of differential equations of interest in mathematical physics. The invited papers are as follows: R. W. Brink, *Oscillation Theorems Associated with Boundary Value Problems;* Rudolph E. Langer, *The Stokes Phenomenon;* and David M. Dennison, *Applications of Approximation Methods to Physical Problems with Particular Reference to Molecular Spectra.*

There will be a joint luncheon for Section A—Mathematics, Section B—Physics, and Section D—Astronomy, on Tuesday, June 25. On Tuesday afternoon Section B—Physics, and Section D—Astronomy, will meet to hear an invited paper by Otto Struve on the subject *Some New Trends in Stellar Spectroscopy.*

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.) Papers received after the program has been printed will be placed in the supplementary program.

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Editorial Secretary, The American Institute of Physics, Incorporated, 11 East 38th Street, New York, N. Y.

Other meetings for the current season are as follows:

200. June 26–29, 1935. Los Angeles, California.
201. November 29–30, 1935. Baltimore, Maryland.
202. December, 1935. Pacific Coast. Time and place to be announced later.
203. December 30–31, 1935–January 1, 1936. St. Louis, Missouri. Annual Meeting.

Harold W. Webb, *Acting Secretary*
Columbia University, New York, N. Y.
June 6, 1935.

CALENDAR

Friday morning, June 21

8:30 o'clock: Lobby of the Physics Building: Registration opens.

9:30 o'clock: Physics Building: Room 166: Papers 1–12. See pages 6–8.

9:30 o'clock: Physics Building: Room 133: Papers 13–27. See pages 8–10.

Friday afternoon, June 21

2:00 o'clock: Informal Conferences. Sports. See Bulletin Board for detailed announcements.

6:00 o'clock: Leave Physics Building or Pioneer Hall for dinner at the Minneapolis Automobile Club.

7:00 o'clock: Dinner followed by Informal Assembly.

Saturday morning, June 22

9:00 o'clock: Physics Building: Room 150: Invited papers on Nuclear Physics, George E. Uhlenbeck presiding and leading the discussion. Invited papers by: H. Bethe, G. Breit, L. R. Hafstad and C. C. Lauritsen. See page 11.

Saturday afternoon, June 22

2:00 o'clock: Cars leave Physics Building or Pioneer Hall for a picnic by the waters of Lake Minnetonka.

Monday, June 24 to Saturday, June 29

ANNUAL SUMMER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Tuesday morning, June 25

Joint session of Section A—Mathematics and Section B—Physics. Invited papers by R. W. Brink, *Oscillation Theorems Associated with Boundary Value Problems;* David M. Dennison, *Applications of Approximation Methods to Physical Problems with Particular Reference to Molecular Spectra;* Rudolph E. Langer, *The Stokes Phenomenon.*

Tuesday noon, June 25

Joint luncheon. Section A—Mathematics, Section B—Physics and Section D—Astronomy.

Tuesday afternoon, June 25

Joint session. Section B—Physics and Section D—Astronomy. Invited paper by Otto Struve, *Some New Trends in Stellar Spectroscopy.*

PROGRAM

FRIDAY MORNING AT 9:30 O'CLOCK

Physics Building, Room 166

Papers Nos. 6 and 9 will be read by title.

1. X-Ray Ionization Chamber Materials. J. N. SAYLER, *University of Iowa.* (Introduced by G. W. Stewart.)—The rate of discharge of alpha particles from materials of possible use in ionization chamber construction has been made by counting the number of particles (having energy in excess of a predetermined minimum) per hour per hundred square centimeters of surface exposed. The following results were found: cold rolled steel 12, electroplated copper (CuCN) 37, commercially electroplated chromium 48, commercially electroplated nickel 31, commercial brass 15, commercial aluminum foil 34, commercial tin foil 47, commercial platinum foil 29, commercial molybdenum 195, Pyrex glass 16. The data confirm and supplement work of Bearden (Johns Hopkins) in 1932. Measurements were made by photographically recording alpha-particle currents in an ionization chamber, amplified by FP-54 vacuum tube system.

2. The Effect of the Spectrometer on the Width of Spectral Lines. ROY C. SPENCER, *University of Nebraska.*—The energy distribution of a spectral line is represented by a function $\phi(x)$. Each ordinate of $\phi(x)$ is spread out by the spectrometer into a curve $F(x)$. Let $\phi(O)=1$ and let the area under the curve $F(x)$ be unity. Then the experimental curve is

$$G(\beta)=\int_{-\infty}^{\infty}\phi(\beta-x)F(x)dx. \qquad (1)$$

The fractional drop at the peak is

$$\phi(O)-G(O)=\int_{-\infty}^{\infty}[1-\phi(-x)]F(x)dx. \qquad (2)$$

This approximates the increase in width at half maximum divided by the width of $G(\beta)$. The factor $[1-\phi(-x)]$ causes the contribution of $F(x)$ to be negligible for small values of x but proportional to the area under $F(x)$ for large values of x. *Application to the Correction of X-Ray Line Widths.* If $\phi(x)$ is a witch of width a, Eq. (2) becomes

$$\phi(O)-G(O)=\int_{-\infty}^{\infty}[x^2/(a^2+x^2)]F(x)dx. \qquad (3)$$

If $x=\tan\theta$

$$\phi(O)-G(O)=\int_{-\pi/2}^{\pi/2}x^2F(x)d\theta. \qquad (4)$$

Eq. (4) is in a form adapted to graphical integ ation. If $F(x)$ is also a witch of width b, Eq. (3) or (4) gives $b/(a+b)$. Over half of the contribution of the integral comes from beyond the point $x=a$. Crystal curves in the (1, −1) position should therefore be measured out as far as possible.

3. Computations Related to Liquid Structure by the Methods of Trial and of Fourier Series Analysis. G. A. BOYD, *University of Iowa.* (Introduced by G. W. Stewart.)—The suggestion has been made that one may obtain useful comparisons with experimental x-ray diffraction in liquids by using a structure consisting of an adjacent organized layer and at a larger distance a uniform distribution of scattering units. This method is found quite unsatisfactory and even misleading in some respects. At any rate it seems that even when extended to other layers this method is not as satisfactory as the Fourier's series method exemplified by the recent work of Pierce with heptane.

4. Effect of Chlorine Ions on X-Ray Diffraction in Aqueous Solution. G. W. STEWART, *University of Iowa.*—This is a record of quantitative measurements of the effect of chlorine ions on the x-ray diffraction of an aqueous solution. In using NH_4Cl, observation was made of the x-ray diffraction for angles less than that of maximum intensity, 12.5°, to 1° using Mo $K\alpha$ radiation. The increase in number of scattering electrons per ccm by the addition of NH_4Cl was 17.7 percent or 12 percent for the Cl^- alone. The diffraction curve showed a fairly constant increase of about 11 percent over the selected range. If the radius of the Cl^- is as usually 1.81×10^{-8} cm and if it occupies a total volume corresponding to a closely packed liquid, the mean density of its electrons in this volume is approximately twice that in the water molecule. With 12 percent of the total scattering units occurring in the regions of a doubled density, an effect of gaseous scattering would be discernible at the small angles. But there is no such effect. Either there is a superstructure or the ion occupies a greater volume than assumed. If Cl^- is as loosely packed as the water molecules a detectable effect would still be expected.

5. The Influence of Chemical Combination on X-Ray Emission Spectra. JOSEPH VALASEK, *University of Minnesota.*—The study of the effect of chemical combination on the K beta lines of sulphur, chlorine and potassium which will be reported in the June 15th issue of *The Physical Review* has been extended to other compounds with the following preliminary results:

COMPOUND	LINE	WAVELENGTH
Na_2S	S $K\beta_1$	5018.06 X.U.
CdS	S $K\beta_1$	5015.87
AgCl	Cl $K\beta_1$	4393.57

Coupled with Stelling's data on the absorption edges, these measurements give information in regard to some of the electronic energy levels in the solid state. The case of AgCl is of interest because of its use in photography. Although the electron affinity of Cl^- as obtained from x-ray data is lower than in any other halide observed as yet, yielding a value of 4.6 electron volts, the value is larger than is to be expected from the photoelectric threshold indicating the presence of a lower energy state which does not enter into the processes observed here.

6. General Theory of Radioactive Fluctuations. ARTHUR E. RUARK, *University of North Carolina.—Generalization of Bateman's equation.* Let $f_n(t)$ be the probability that an event occurs in dt at t, when n have occurred in the interval O, t. Let W_n be the probability of n events in this interval. Then $dW_n/dt = f_{n-1}W_{n-1} - f_nW_n$. (1) For a source containing N atoms initially, $f_n = (N-n)\lambda$; $W_n = C_n^N(e^{\lambda t}-1)^n e^{-N\lambda t}$. (2) Suppose f depends on t, but not explicitly on n. Then $W_n = x^n e^{-x}/n!$ where $x = \int_0^t f(t)dt$. *Effect of solid angle subtended by detecting device.* Statements in the literature that the use of small solid angle prevents us from testing the random character of radioactive decay are wrong. There is a unique connection between W_n and the probability P_m for ejection of m particles into solid angle ω in time t. Let $\omega/4\pi = g$. For a source containing N atoms

$$P_m = W_m g^m[1+(e^{\lambda t}-1)(1-g)]^{N-m}.$$

For a "constant" source giving f particles/sec., P_m is given by Bateman's formula with fg substituted for f. These facts necessitate reconsideration of data on decay constants of artificially radioactive substances.

7. The Desorptive Action of Radon. E. L. HARRINGTON AND H. H. PENLEY, *University of Saskatchewan.*—Observations made in the course of the routine operation of a radon plant pointed to the conclusion that when radon is admitted to a vacuum system adsorbed gases, not readily removable by vacuum pumps, are released (or else are formed) by the action of the radon. An experimental investigation of the problem has yielded results supporting the conclusion.

8. A Multiple Column Mercury Manometer. J. R. ROEBUCK AND WINSTON CRAM, *University of Wisconsin.*—An open-tube multiple-column mercury manometer has been constructed. It consists of nine U tubes, approximately 17.5 meters long, connected in series. Toluene is used to transmit the pressure from one mercury surface to the next. A level reading device is placed at the top and the bottom of each U tube. It consists of a contact point moved in a one-inch diameter tube by a nut running on a micrometer screw driven from the outside through a packed joint. The connecting tubes of $\frac{1}{16}$ inch I.D., $\frac{1}{4}$ inch O.D. steel tubing are each enclosed in a larger pipe which forms part of a circulating oil bath for the control of the temperature. The temperatures of the liquids are read by seven mercury thermometers placed in different parts of the system. A Société Génévoise invar tape is used to measure the distance between contacting devices. The system has been connected so that any pressure below 192 atmospheres can be measured. The accuracy of pressure measurements depends on (1) the measurement of the length of the mercury columns, (2) the determination of the densities of the two liquids as a function of room temperatures and (3) the control of the temperature. The instrument is being tested by measuring the vapor pressure of carbon dioxide at the ice point.

9. The Principal Expansion Coefficients of Single Crystals of Mercury. DONALD M. HILL, *Rutgers University.*—The expansion coefficients were measured at 5° intervals from −115°C to −160°C, where the pentane bath became too viscous to use, and mean values found from −160°C to −190°C. The upper limit of the measurements was set by a recrystallization process which set in between −115°C and −110°C. $\alpha_{||}$ was found to be larger and to increase more rapidly with the temperature than $\alpha_{\perp}$. Carpenter and Oakley[1] measured the volume coefficient near the melting point and interpreted their data as a linear relation with the temperature. The present measurements at lower temperatures show that the relation is not linear and, when plotted in conjunction with Carpenter and Oakley's values, give values of the volume coefficient from the melting point to −160°C where the coefficient apparently begins to decrease rapidly with the temperature. Several crystals were found which had lower specific resistances than the values for $\rho_{||}$ given by Grüneisen and Sckell.[2] The experimental data and curves are ready for publication.

[1] L. G. Carpenter and F. H. Oakley, Phil. Mag. **12**, 511 (1931).
[2] E. Grüneisen and O. Sckell, Ann. d. Physik **19**, 387 (1934).

10. Thermal Equilibrium of the Gas in the d.c. Carbon Arc. W. T. GRAY, *Northwestern University.* (Introduced by W. S. Huxford.)—The rotational temperature of the cyanogen molecules has been determined in d.c. carbon arcs, using a standard projector carbon. A 10-foot concave grating in a Rowland mounting was used for the band exposures and a quartz spectrograph with an 8-step diaphragm for the density marks. The relative intensities of the rotational lines show a Maxwell-Boltzmann distribution of rotational energies in the (0,0) λ3883 and (0,1) λ4216 CN bands. The temperature corresponding to this distribution is 5300°±300°K over the current range from 7 to 21 amperes. By reflecting the arc light through the hot gas, it was found that self-absorption had no effect upon the relative intensities. The range of rotational lines in the (0,1) band was extended by using several lines beyond the head of the (1,2) band. Independent measurements of the temperature in the outer flame of the arc, using the method of line reversal, have been extrapolated to include the central region. The mean temperature of the violet kernel obtained from the curve which gives the radial reversal temperature distribution is in good agreement with the rotational temperature of the CN molecules, which are excited only within this region.

11. An Inexpensive d.c. Amplifier. R. D. HUNTOON, *University of Iowa.* (Introduced by A. Ellett.)—A circuit using a commercial type 2A6 vacuum tube to measure currents of the order of 10^{-13} ampere with a wall galvanometer is discussed. Modifications necessary to construct a portable amplifier with a sensitivity of 10^{-11} amp. which may be operated directly from a.c. mains are shown. A simplified balancing procedure is outlined.

12. Statistical Distribution Curves in the Radio Tube Industry. WALTER DEHLINGER, *Hygrade Sylvania Corporation, Emporium, Pa.*—Statistical considerations have played an important part in physics during the last ten years. Many industries have taken advantage of this development. For a long time, the theory of small samples has been the focus of interest. Economical considerations

would naturally encourage this trend for this application of statistics. The trend is now in the direction of establishing standard distribution curves for the characteristics of the various types of tubes. This means a slight increase in inspection but a great saving of losses due to shrinkage and a considerable improvement in quality. The standard curves, which are prepared from samples of several thousand tubes per type by means of a Hollerith machine, are discussed. A daily check for distribution type is made from samples of about 200 tubes. A variation of the shape of the distribution curve indicates the approach of trouble before the shrinkage has increased. The cause of the trouble may be found and eliminated before a serious loss due to shrinkage takes place. The character of the distribution curves was designated in the beginning of the development as Maxwellian and Fermian, corresponding to their shapes. Practical application soon indicated the way to three types of distribution curves connected with the main characteristics of a radio tube: (1) Plate Current Type, (2) Emission Type, (3) Mixed or Gauss Type. The operation of the system is described and further developments of the method and its applications are discussed.

Friday Morning at 9:30 o'clock

Physics Building, Room 133

Papers Nos. 15 and 27 will be read by title.

13. Λ-Type Doubling Widths in $^3\Pi$ States of Molecules Intermediate between Hund's Cases (a) and (b). M. H. Hebb, *Harvard University.*—The theoretical work of Van Vleck on Λ-type doubling has been extended to molecules in $^3\Pi$ states, making no assumption about the magnitude of the ratio B/A. With unperturbed representation appropriate to Hund's case (a), general formulas for the doubling widths have been set up, which are valid through the entire range from Hund's case (a) to case (b). It is shown that the rotational distortion causes a gradual transition away from case (a) for small J toward case (b) as J increases. This means a mixing of the $^3\Pi_2$, $^3\Pi_1$ and $^3\Pi_0$ states of case (a) with consequent sharing of the Λ-type doubling widths. The theory has been applied to the experimental data of Naudé on N_2 with good agreement.

14. Isotope Relations in the Spectra of LiH and LiD. F. H. Crawford and T. Jorgensen, Jr., *Harvard University.*—The authors have called attention (Phys. Rev. June 15, 1935) to the fact that the failure of the simple isotope theory in hydride and deuteride molecules is in part due to the neglect of the effect of certain correction terms predicted by Dunham (Phys. Rev. **41**, 721 (1932)). Thus the constants determined from an *empirical* analysis of a band spectrum differ from the ordinary mechanically significant molecular constants by terms in $(B_e/\omega_e)^2$. In general, $Y_{lj}=f(\omega_e B_e)[\alpha_{lj}+\beta_{lj}(B_e/\omega_e)^2+\cdots]$ where the correction coefficients β_{lj} involve the coefficients a_1, a_2, $a_3\cdots$ in the potential energy function of the usual Kratzer form. Provided sufficiently extensive and precise data are available it is possible to compute these coefficients with considerable accuracy. Unfortunately these data are available only for a few states of H_2 and for LiH (and LiD). We have accordingly determined these coefficients from a_1 to a_5 and find for the *ground* state of LiH that the corrections are appreciable. Thus the ratios $[B_e^i/B_e]^{\frac{1}{2}}$ and ω_e^i/ω_e are respectively $(\rho+0.000184)$ and $(\rho+0.000217)$, where ρ is the isotope ratio determined from mass-spectrograph values ($\rho=0.750486$), where the differences are now presumably direct measures of the effect of the "nuclear wobbling" caused by electronic motions [discussed by Kronig, Physica **1**, 617 (1934)].

15. The Application of Integral Equations to Eigenvalue Problems in Quantum Mechanics. A. F. Stevenson, *University of Toronto.*—It is shown that the wave-function for the discrete spectrum in a one-electron problem satisfies an integral equation which is analogous to that occurring in Born's theory of scattering by a static field, the energy occurring (non-linearly) as an unknown parameter. The solution of the equation by successive approximations, starting from assumed initial approximations to energy and wave-function, is discussed. In the case of perturbations, the first approximation to the energy leads to a result which is identical, to the first order in the perturbation, with that obtained from the ordinary theory, while the second approximation should yield a result comparable in accuracy with that obtained from the second-order perturbation in the usual theory. The calculation of the integrals involved is discussed and a simple example where the correct solution is known is considered in order to test the efficacy of the method. The extension of the integral equation to the general case is also given.

16. The Scattering of Slow Neutrons by Heavy Atoms. J. H. Van Vleck, *Harvard University.* Bethe has shown that the anomalously large scattering or absorption reported by Fermi, Dunning and Pegram is to be expected whenever the integral $I=2\int_0^R[2M(W-V)/h^2]dr$ is a half integer, where R is the nuclear radius. The value of I has been computed with the Thomas-Fermi statistical model of the nucleus and the Majorana form of the neutron-proton interaction. The constants for this interaction have been taken from the work of Feenberg. The values of I turn out too small to permit the interpretation of the anomalous scattering in Hg, for instance, as due to an additional node as compared with Cd.

17. Photoelectric Properties of Pure and Gas Contaminated Magnesium. R. J. CASHMAN AND W. S. HUXFORD, *Northwestern University.*—Specially purified samples of magnesium metal were freed from gas by successive distillations and very slow sublimation in a high vacuum. The photoelectric threshold was found to lie at 3430±20A, both for layers deposited on molybdenum and tantalum plates and for those deposited on the glass walls of the tube. A threshold characteristic of hydrogen contaminated surfaces lies at 5100A. Minute amounts of oxygen sensitize pure magnesium, causing a shift in the threshold to about 6000A. Further exposure of this sensitized surface to small amounts of oxygen results in deactivation, and a recession of the threshold to a value below 2000A. Air and hydrogen, or mixtures of oxygen and hydrogen, cause a marked increase in emission, with excursions of the long wave limit to 7000A and beyond. Magnesium surfaces are sensitized by nitrogen only when a glow discharge is set up in the gas. These changes in work-function are explained on the hypothesis that surface films of polar non-homonuclear molecules are formed by the action of the various gases. Fowler's theory is found to hold accurately for magnesium surfaces activated by hydrogen, the apparent threshold at 5100A being changed to the true value 5040A.

18. Scattering Intensity of Electrons as a Function of Voltage. H. J. YEARIAN AND J. D. HOWE. (Introduced by K. Lark-Horovitz, Purdue University.*)—Electrons of 10 to 80 kv are diffracted by gold and silver films in the way described previously.[1] The diffracted intensity is determined photographically and the coherent scattering plotted as a function of angle. It has been found that the scattered intensity at voltages below the K absorption limit of the element investigated cannot be accounted for by the usual first approximation of Born and Mott.[2] Instead of a smooth curve for the amplitude of scattering as a function of angle, maxima are observed of the type predicted by the further approximation of Henneberg which takes into account the distortion of the electron waves by the diffracting atom.[3]

* Grateful acknowledgment is made to the American Philosophical Society for a grant-in-aid of this research. (K. L.-H.)

[1] K. Lark-Horovitz, H. J. Yearian and J. D. Howe, Phys. Rev. **47**, 331 (1935).

[2] Born, Zeits. f. Physik **38**, 803 (1926); Mott, Proc. Roy. Soc. **A127**, 658 (1930).

[3] Henneberg, Zeits. f. Physik **83**, 555 (1933).

19. The Scattering of Potassium Ions by Mercury Vapor. ARTHUR G. ROUSE, *University of Iowa.* (Introduced by John A. Eldridge.)—An apparatus has been designed to measure the scattering at large angles of potassium ions by mercury vapor. Neglecting effects at small angles, both the classical kinetic theory or wave mechanics lead to a uniform scattering function for a rigid sphere model; for "softer" molecules they lead to a predominance in the forward direction; and for a Coulomb law force to the familiar Rutherford relation. Zabel has shown that for uncharged heavy atoms, moving with thermal velocities, the rigid sphere model is satisfactory. In the present work it is found that with K^+ ions with energies between 20 and 300 e-volts the scattering is predominately in the forward direction.

20. Electron Diffraction by Gas Molecules; (I) Structure of Phosphorus, (II) Valence Angle of Oxygen. LOUIS R. MAXWELL, V. M. MOSLEY AND STERLING B. HENDRICKS, *Bureau of Chemistry and Soils, Washington, D. C.*—(I) Electron diffraction photographs have been obtained from gas molecules of phosphorus (P_4), for deBroglie wavelengths ranging from 0.080A to 0.055A. Four different methods were used for analyzing the photographs obtained, as follows: (1) visual measurements, (2) measurements of densitometer records, (3) conversion of densitometer records into relative intensity curves by the use of plate calibrations for electrons, (4) use of a comparison between experimental and complete theoretical intensity curves in which each value of the intensity is multiplied by $[(1/\lambda)\sin\theta/2]^2$ in order to produce real maxima for measurement in all cases. By considering the results obtained from these different methods of treatment the most probable form of the P_4 molecule was found to be a regular tetrahedron with a P–P distance of 2.21±0.02A. This distance is in agreement with recent x-ray studies on black amorphous and crystalline phosphorus (Gingrich and Hultgren; Hultgren and Warren, Washington meeting 1935). (II) The valence angle of oxygen α was measured by electron diffraction in a similar manner for the molecule 4,4′ diiododiphenyl ether $(C_6H_4I)_2O$. Complete theoretical intensity curves were computed for $\alpha=90°$, 110°, 120° and 180°. The model $\alpha=120°$ gave the best fit with the experimental results. By interpolation, it is estimated that the most probable value for the valence angle of oxygen in this molecule is 118°±3°.

21. A Study of the First Spark Spectrum of Caesium as Excited by Electron Impact. ROY R. SULLIVAN, *University of Minnesota.*—An apparatus with which one may study the controlled excitation of spectra of volatile metals is described. Certain aspects of the optical excitation functions for several Cs II lines have been determined. A comparison of onset potentials found experimentally with those predicted by existing energy level schemes is made. Possible transitions are suggested for the two unclassified lines λλ4264.7 and 4763.6. Of the two groups into which the Cs II spectrum divides itself, the lines coming from terms built upon the $^2P_{\frac{1}{2}}$ state of Cs III show very broad excitation function maxima, while the lines coming from those terms built upon the $^2P_{1\frac{1}{2}}$ state of Cs III show relatively sharp maxima.

22. Optical Excitation of HgH and CN Bands. LEONARD O. OLSEN, *University of Iowa.* (Introduced by A. Ellett.)—Hg Vapor in the presence of 0.01 mm H_2 and about 3 mm N_2 was irradiated with the light from either an Hg+H_2 or Hg+He discharge. In both cases there occurred a weak excitation of the $^2\Pi-{}^2\Sigma$ HgH bands. There was no evidence of optical excitation of the HgH bands, such as occurs with CdH and ZnH. Evidently the HgH molecule in its normal state dissociates very quickly, as Wood and Gaviola have supposed. The HgH bands are evidently excited by collision and were obtained when only the 6^3P states of the Hg were excited, but the precise mechanism is not clear.

$$H_2+Hg(6^3P)\rightarrow HgH(^3\Pi)+H$$
$$H+Hg(6^3P)\rightarrow HgH(^3\Pi)$$

appear to be excluded by energy considerations. At one time there was observed strong emission of the λ3383A CN bands, evidently due to cyanogen formed from organic vapors (stop-cock grease) and excited by collisions of the second kind.

23. Effect of a Magnetic Field Upon the Polarization of Impact Radiation. W. H. McCorkle, *University of Iowa.* (Now at Agricultural and Mechanical College, College Station, Texas.) (Introduced by A. Ellett.)—Sodium *D*-line radiation excited by electrons moving parallel to a magnetic field of 300 gauss or more shows about 16 percent polarization, the major electric vibration being parallel to the direction of the exciting electron beam. In fields below 300 gauss the polarization is less, decreasing to zero in the absence of a field. That the polarization changes in a magnetic field must be due to the fact that the $3^2P_{\frac{1}{2}}$ level is a hyperfine multiplet which undergoes Paschen-Back effect.

24. Dissociation of NO and HCl by Electron Impact. Elmo E. Hanson, *University of Minnesota.*—By means of an apparatus of the type used by Lozier a study has been made of ionization with dissociation in NO and HCl. Ions possessing a considerable amount of kinetic energy were found in each of these gases and their distribution in energy was measured as a function of the electron energy. From determinations of the least electron energy necessary to form an ion having a specific kinetic energy it was possible to calculate the heat of dissociation of the molecular ion and of the normal molecule. The following is a summary of the results and the assumed processes. Unless specified the products are in their normal states.

PROCESS	KINETIC ENERGIES	HEAT OF DISSOCIATION
$NO\rightarrow N+O$		5.2 ±.2 volts
$NO^+\rightarrow N^++O(^1D_2)$	0 to 6 volts	
$NO^+\rightarrow N+O^+$		9.37±.2
$NO+e\rightarrow N+O^-$	1 to 2.5	ELECTRON AFFINITY OF O = 1.9 ±.5
$HCl\rightarrow H+Cl$		4.7 ±.2
$HCl^+\rightarrow H^++Cl$	0 to 10	
$HCl^+\rightarrow H+Cl^+$		4.7 ±.2
$HCl+e\rightarrow H+Cl^-$	LESS THAN 0.5	

The kinetic energy distribution curves for ions formed in HCl showed a peculiar three-peaked structure for electron energies above 40 volts.

25. The Ionization of Hydrogen Chloride under Electron Impact. Alfred O. Nier and Elmo E. Hanson, *University of Minnesota.*—A mass spectroscopic investigation has been made of the ions produced in HCl under electron impact. The following ions were observed: HCl^+, HCl^{2+}, H^+, Cl^+, Cl^{2+}, Cl^{3+}, Cl^{4+}, Cl^{5+} and Cl^-. Using He and Ne as calibrating gases the following appearance potentials were observed: HCl^+, 12.9±0.2 volts; HCl^{2+}, 35.7±1.0; H^+, 18.6±0.3 and 28.4±0.3; Cl^+, 17.2±0.5 and 21.2±0.5; Cl^{2+}, 45.7±0.3; Cl^{3+}, approximately 160; Cl^-, approximately 1.6 volts. The Cl^{4+} and Cl^{5+} peaks were too small for the determination of their appearance potentials. No H_2^+ or Cl_2^+ ions were observed. The efficiency of ionization curves were of the usual form. Special precautions were taken to reduce to a minimum the amount of water vapor present in the tube and it can be stated with certainty that the H^+ ions found were not caused by the presence of water vapor. From the ratio of the peak heights of HCl^{35} to HCl^{37} the abundance ratio of Cl^{35} to Cl^{37} was found to be 3.07±0.03. Cl^{39} if present was less than 1/20,000 of Cl^{35}.

26. Spectral Emissivities of Columbium, Thorium, Rhodium and Molybdenum. L. V. Whitney, *University of Wisconsin.*—To establish an accurate temperature scale spectral emissivities for columbium, thorium, rhodium, and molybdenum were measured at $\lambda = .667\mu$. The Mendenhall V wedge was used for columbium and rolled cylinders were used for the other metals. The rolled cylinders used to measure black body and brightness temperatures proved superior to other forms of specimens and results should be more reliable. Rigorous outgassing treatment was found necessary for accurate results. Emissivities for all four metals were constant with temperatures over the ranges measured. Results are:

	EMISSIVITY $\lambda = .667\mu$	TEMPERATURE RANGE COVERED
Columbium	0.374	1300°–2200°K
Thorium	0.380	1300°–1700°K
Rhodium	0.242	1300°–2000°K
Molybdenum	0.382	1300°–2100°K

27. A Rydberg Series in I(I). W. C. Price, *The Johns Hopkins University.*—A well developed series has been found in Turner's data on the far ultraviolet spectrum of I(I) (L. A. Turner, Phys. Rev. **27**, 397 (1926)). It conforms within the experimental error to the Rydberg-Ritz formula

$$=79{,}210-R/(n-4.129+(0.105/n^{*2}))^2 \qquad n=6,\ 7,\ 8.$$

The lower state is the $5p\ ^2P_{\frac{1}{2}}$ state of I(I) and the series probably goes to the $^3P_0$ state of the ion. The series arising from $5p\ ^2P_{\frac{3}{2}}$ is weaker and only a few terms are observed. If the doublet separation of 7600 cm^{-1} is added to the limit given above, we get 10.71 volts as an ionization potential of I(I). This is not the lowest ionization potential as the ground state of I(II) is probably $^3P_2$ (jj coupling is closely approached). The separation $^3P_0-{}^3P_2$ is estimated to be a few tenths of a volt. It must be subtracted from the value given above to get the lowest ionization potential of I(I).

SATURDAY MORNING AT 9:00 O'CLOCK

Physics Building, Room 150

SYMPOSIUM

ON

NUCLEAR PHYSICS

GEORGE E. UHLENBECK, presiding

28. **Some Current Nuclear-Physics Problems in the Region Below 1000 Kilovolts.** L. R. HAFSTAD, *Carnegie Institution of Washington.* (30 minutes.)

29. **Rates of Nuclear Reactions Due to Bombardment with Charged Particles.** G. BREIT, *University of Wisconsin.* (30 minutes.)

30. **Gamma Rays and Electrons from the Transmutation of Some Light Elements.** C. C. LAURITSEN, *California Institute of Technology.* (30 minutes.)

31. **Nuclear Structure and Stability.** H. BETHE, *Cornell University.* (30 minutes.)

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.

Paper No. 32 will be read by title. Papers Nos. 33–36 will be called for in Room 166 after Paper No. 12.

32. **Distribution of Counts in a Counter with Constant Recovery Time.** ARTHUR E. RUARK, *University of North Carolina.*—Skinner (Bull. Am. Phys. Soc. **10**, No. 2, p. 12) has considered the efficiency of counters and the distribution of recovery times. The theory of the distribution of counts, taking variability of the recovery time into account, will be very complicated. To get an approximate theory, we assume a constant recovery time, τ. Let f be the average number of ionizing particles (not counts!) per sec. and $P_n(t)$ the probability of n counts in an interval t, after a count has occurred. The functions P_n can be obtained seriatim. We have: $P_0=1$ for $t\leqq\tau$; $P_0=e^{-f(t-\tau)}$ for $t\leqq\tau$. $P_1=0$ for $t\leqq\tau$; $P_1=1-e^{-f(t-\tau)}$ for $\tau\leqq t\leqq 2\tau$;

$$P_1=e^{-f(t-2\tau)}[1+f(t-2\tau)]-e^{-f(t-\tau)}$$

for $t\leqq 2\tau$; and so on. P_n obeys a difference-differential equation, which has so far proved intractable in the general case.

33. **The Magnitude of the *K*-Absorption Discontinuity for Tin and for Silver.** E. L. HARRINGTON AND G. A. WIENSHALL, *University of Saskatchewan.*—An experimental study of the variation of the mass absorption coefficient with wavelength has been made for tin and for silver and the magnitudes of the *K*-discontinuity for each metal determined on the basis of the results obtained. The apparatus employed included a Bragg x-ray spectrometer provided with rotating sectored disks and a twin ionization chamber.

34. **The Low-Frequency Electrodeless Ring Discharge.** F. H. CRAWFORD AND C. G. SMITH, *Harvard University.*—Although the electrodeless discharge in low pressure gases has been studied extensively at radiofrequencies, no attempts seem to have been made to determine the conditions for successful operation at *low frequencies* (<6000 cycles). The possibility of using *iron* and relatively large powered generators both point to the possibility of greatly increased currents. Actually by using properly designed step-down transformers having a few turns of heavy wire in the primary, and a single "turn" of low pressure gas as a "secondary," it has been possible to obtain quite heavy dis-

charges in various gases at pressures of 10^{-4} mm of mercury and frequencies of 5400 and 900~. The magnetic circuit must be constructed with the best iron and have as little magnetic leakage as possible. Operation has been obtained with Cs and Hg vapors when the ordinary and the first ionized spectra are strongly developed. Under the most favorable conditions currents of over 400 amperes have been obtained (with a 10 kw generator and Hg at 10^{-4} mm) without serious heating of the tube. The use of this type of discharge for the intense excitation of molecular spectra and as a possible rich source of positive ions is suggested.

35. Temperatures Generated by the Passage of High-Frequency Alternating Currents through Animal Tissue with Special Reference to Electro-Surgery. R. D. HUNTOON, *University of Iowa.* (Introduced by A. Ellett.)—The temperature rise caused by the flow of high frequency currents through tissue was measured by means of thermocouples. Various sources of error were investigated and means of elimination devised. Measurements in the close vicinity of cutting and coagulating electrodes, as normally used in electro-surgery, are compared with previous measurements and the large observed differences explained on the basis of the observed effects of high frequency currents on improperly protected thermocouples.

36. Sources of Asymmetry in X-Ray Diffraction Grating and Refraction Measurements. ROY C. SPENCER, *University of Nebraska.*—If the product of the x-ray line function and the asymmetrical function is $(a+2\theta)/(b^2+\theta^2)$, then the shift in the peak is b^2/a. The shifts in the following cases are, however, too small to affect present wavelength measurements. *Case 1.* X-ray diffraction grating at grazing angles. The variation in dispersion causes an asymmetry in the x-ray line (which consists of a range of wavelengths). *Case 2.* The ordinary grating formula for N slits indicates an asymmetry in the peak due to the single slit pattern. *Case 3.* Refraction through a prism placed between the crystals of a double crystal spectrometer. The angular width of the x-ray line reflected from the first crystal causes a variation in the angle of incidence which causes both a variation in the coefficient of transmission and a variation in dispersion. Both effects cause asymmetry. *Case 4.* The diffraction pattern for parallel light passing through an absorbing prism is derived. It is a witch for angles near the normal but is asymmetrical near grazing angles.